

Perchlorate Biodegradation Technologies

Problem

Three Perchlorate Problem Areas Defined

- Wastewater from propellant manufacture & handling operations
- Groundwater near manufacturing and end-use facilities
- Drinking water contamination



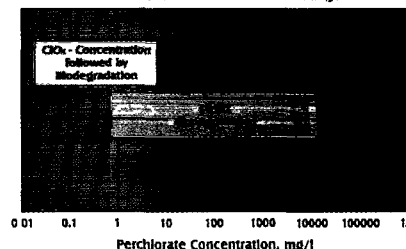
Propellant removal and destruction

Solution

Proven Perchlorate Biodegradation Processes Developed by ARA

- Reduces perchlorate to chloride
- Reduces perchlorate concentration to below detection limits
- Effective from parts-per-billion to percent perchlorate concentrations
- Effective with high concentrations of co-contaminants
 - Grams per liter of nitrate, chlorate, sulfate, ammonium
 - Greater than 3% total dissolved solids
 - Dissolved metals and VOCs
- A very robust process – successfully treating industrial wastes since 1997

Biological Treatment Approaches Effective Over Wide Concentration Range



ARA has a long history of Perchlorate Biodegradation R&D...



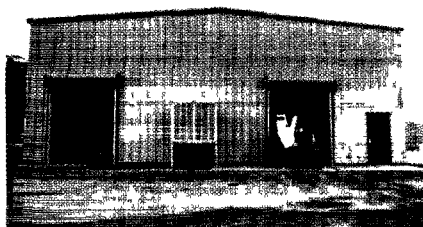
Pilot scale demonstration

- 1990 – Isolated a bacterial culture that reduces perchlorate
- 1991-1993 – Developed process that led to Air Force Patent 5,302,285
- 1994-1996 – Designed, built, and demonstrated pilot-scale systems
- 1997 – Designed and built a prototype wastewater treatment system
- Sep 1997 – Initiated treatability studies on groundwater from Henderson, NV
- Dec 1997 – Inoculated and initiated continuous operation of Thiokol prototype
- Jun 1998 – Demonstrated perchlorate reduction in ion exchange brine
- Jan 1999 – Completed preliminary full-scale designs for groundwater treatment plant

Industrial Wastewater Treatment:

- The Thiokol prototype facilitates recovery and reuse of propellant ingredients and rocket motor components
- Treats KCl brine containing perchlorate and nitrate from ion exchange and precipitation processes
- ARA provided project management, design, engineering, construction, and start-up
- ARA completed the project within original budget and schedule
- The prototype has been operational since December 1997

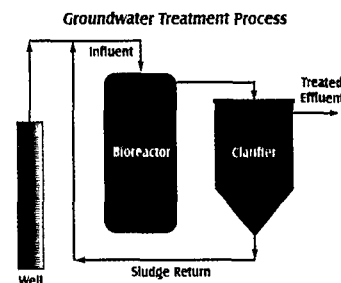
*Thiokol prototype facility
and reactors*



Groundwater Remediation

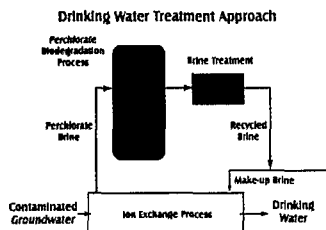
ARA Developed a Process to Treat Highly Contaminated Groundwater from Near Henderson, NV

- Completed preliminary process designs for 50 to 450 gpm facilities
- Capable of reducing 1,000-2,000 pounds of perchlorate per day
- Uses locally available, low-cost nutrients
- O&M Costs (nutrients, chemicals, power, labor) projected to be < \$1/Kg of perchlorate
- Over 18,000 hours of bench-scale evaluation and optimization
- Process is not affected by co-contaminants or indigenous microbes



Drinking Water Purification

ARA's Biodegradation Process Effectively Reduces Perchlorate Ion Exchange Brines

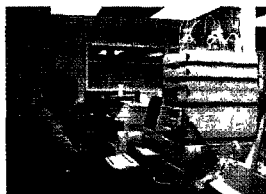


- Integration of biodegradation and ion exchange technologies
- Enables treatment of large volumes with a small biodegradation process
- Effluent can be discharged to local POTW
- Integrated process is cost-effective: \$100-\$200 per acre-foot
- Developed proprietary, non-biological, non-catalytic process to enable brine reuse
- Patents pending

Panama City Facility

Providing Process Development and Treatability Evaluations for a broad range of Wastewater and Groundwater applications...

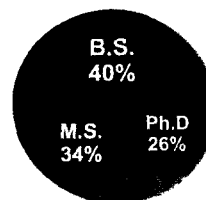
- Operate many reactor configurations: flow, batch, sequencing batch, fixed-film, and suspended growth
- Full analytical capability: ion and gas chromatography, HPLC, wet chemistry, physical and biological testing
- Maintain microbial cultures: grow, identify, adapt, conduct diagnostics



Company Profile

ARA is a progressive small business with 238 accomplished engineers and scientists, 60% with advanced degrees. Employee ownership helps ensure the integrity and high caliber of project performance that our clients expect. Our great strength lies in the ability to recruit and retain renowned experts from diverse technical fields, thus continuously broadening the scope of our capabilities and services. Our results are:

- 20 Years of Excellent Project Performance
- FY 98 Sales of \$48.3 Million
- 30% Compound Growth Rate



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